

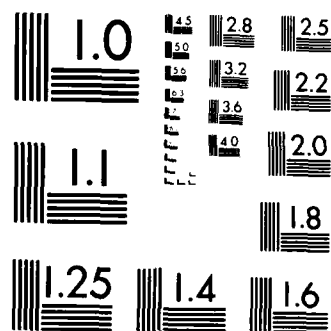
GAME-STRUCTURED ANALYSIS AS A FRAMEWORK FOR DEFENSE  
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GAME-STRUCTURED ANALYSIS AS A FRAMEWORK FOR DEFENSE PLANNING

Paul K. Davis

January 1985

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## PREFACE

This paper is the outgrowth of an invited speech to the German Strategy Forum in Bonn-Bad Godesberg, West Germany, on December 3, 1984. It is addressed to those who are already inclined to believe in the desirability, importance, and feasibility of conventional defense for NATO. More particularly, it is directed to those who are also concerned about how formal analysis can be made more relevant, constructive, and persuasive in the continuing effort to improve NATO's defense posture.

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## SUMMARY

The debate about NATO'S defense options has changed little in more than twenty years, with even less convergence of views. This nonconvergence has its principal origins in politics, economics, and the sociology of democracies, but the problem has been exacerbated by the absence of a coherent analytic framework within which to force issues toward resolution. Indeed, specialists in NATO defense issues fall into several disjoint groups with little intergroup communication--and few serious efforts to resolve differences, coalesce on recommendations, and advocate actions with the weight of consensus. It is then not surprising that it has been difficult to formulate, agree on, and maintain continuity in NATO's improvement programs. It is also not surprising that proposed initiatives all too often lack coherence and balance.

Fortunately, the environment is now changing and the prospect exists for a more enlightened approach that would regularly bring together military officers, historians, technologists, and quantitative analysts--both those concerned primarily with simple models and resource issues and those concerned primarily with the phenomena of warfare and simulation models. The improved environment includes increased interest in analytic realism, operational relevance, combined-arms planning, and in actually *solving* military problems.

With this background, then, *the major point of this paper is that defense planning in the new environment should increasingly make use of conceptual structures akin to global political-military war gaming.* Such planning--whether for evaluating future force-structure options or near-term operations plans--should represent faithfully the asymmetric capabilities, operational strategies, and objectives of the two sides; it should also emphasize beginning-to-end global scenarios, taking into account possible mechanisms of escalation and termination and reflecting the nuclear shadow's effect on conventional operations. The concepts and techniques for such analysis are now becoming available.

Some of the consequences of game-structured analysis with modern analytic models will be: (1) *multiscenario analysis*, to better account for the uncertainties attending any discussion of possible conflict, and (2) the development of *diverse and complex strategies*--strategies with branches for different circumstances and with explicit recognition of the need to exploit opportunities as well as cope with difficulties. The possibility exists that game-structured analysis could become a unifying framework within which many chronically unresolved debates could be joined and in which strategic thinking and a more aggressive approach to practical problem solving would be encouraged.

If there is indeed to be a convergence of strategic thinking, however, there are numerous necessary conditions. In particular, quantitatively inclined analysts must make their models more relevant to the issues being debated by strategists. Their models must be unequivocally strategic in perspective, flexible enough to address a vast range of "What if?" questions, transparent enough to establish credibility, and interactive enough to allow people other than inveterate modeler-analysts to use the models directly. Finally, there must be progress on what has long been promised but never truly delivered: relating assumptions in the aggregated strategic-level models to insights gained from empirical experience and detailed studies. This paper describes recent progress on many of these issues in the Rand Strategy Assessment Center (RSAC). It also proposes a cross-national cross-cultural effort to develop an improved analytic framework that could be used throughout the NATO community.

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## I. INTRODUCTION

### A CONTEXT OF NONCONVERGENCE

One remarkable feature about the continuing debate on how best to defend Western Europe is the constancy of the issues. Another remarkable feature is the lack of convergence over a period of twenty years or so. Figure 1 reminds us of some of those enduring issues.

Even when we get past the larger themes of Fig. 1, there remain many issues and disputes about down-to-earth defense programs and operational strategies (Fig. 2). Although neither complete nor entirely

- 
- o Nuclear deterrence is not (or is) sufficiently credible
  - o Conventional defense is (or is not) feasible given the modest (or large) quantitative superiority of the Warsaw Pact forces
  - o Increasing reliance on conventional defenses would raise (or lower) overall deterrence while raising the nuclear threshold
  - o Improving conventional defenses is (or is not) feasible given realistic estimates of the requirements and the implications for budgets and manpower
  - o Europeans already shoulder (or should shoulder) most of the burden for defense of Europe
  - o NATO's air forces would (or would not) compensate significantly for Pact advantages in numbers of divisions
  - o The real threat is from a lengthy war in which the Soviets can exploit the sheer magnitude of their land army (or a blitzkrieg with minimal warning)
  - o In time of multifront crises the United States would (or would not) have to focus its attention solely on Europe, to the exclusion of the other fronts
- 

Fig. 1 -- Persistent themes in the debate about defense of Europe

- 
- o Forward defense is the best (or worst) use of NATO's limited forces
  - o We should not (or should) consider alternatives such as defense in depth and mobile defense
  - o Modernization should (or should not) focus on "heavying up" NATO's divisions; ultimately, firepower and mobility dominate (or are only one factor)
  - o The focus of improvements in conventional defense should be:
    - additional operational reserves
    - (or heavier divisions)
    - (or smart munitions for second-echelon interdiction)
    - (or smart munitions for use on the front and in battlefield interdiction)
    - (or systems for advanced command and control, including theaterwide situation assessment)
    - (or preparations for a long war with increased buys of munitions and spare parts, and plans for mobilization)
  - o The focus of thinking in conventional defense should be on deterring the short war (or the long war)
  - o The biggest threat is a short-warning (or full-mobilization) attack
  - o NATO partners should (or should not) plan for defense actions outside the NATO area per se, particularly in Southwest Asia
- 

Fig. 2 -- Enduring disagreements about NATO options

fair-minded, Fig. 2 is valid insofar as it conveys a sense of continuing confusion and a sense that the landscape of options is broad.<sup>1</sup>

Given the continuing arguments about fundamentals as well as improvement options, it is surprising that there has been any progress at all. Still, in spite of the massive Soviet buildups throughout the 1970s and into the current era, now is a reasonably good period for NATO in some respects because the fruits of modernization programs are becoming felt. It is also a period in which the United States has taken substantial measures to improve readiness across the board and to raise the status of the military in public eyes. Morale in the military is

---

<sup>1</sup>See, for example, Levine, Connors, Weiner, and Wise (1982).

good and there is a sense that problems can be solved and needed improvements achieved.<sup>2</sup> Another good development has been the increased attention paid to operational commanders--even to the extent of providing them directly with funds for miscellaneous problem-solving best done in the field. Finally, some of the new technology is here and impressive. Over the next decade it should be possible to field defensive systems with extraordinary capabilities.

In spite of these optimistic comments, there has not yet emerged a consensus among NATO members about how best to proceed toward an adequate conventional defense in the course of a finite number of years; nor is there adequate attention at the policy level to the kinds of problems that money will not solve--e.g., problems of multinational operations in the presence of Soviet blitzkrieg tactics. Indeed, far short of that, *there is still no consensus on the most fundamental of issues: the importance of NATO's being able to defend itself conventionally, with some confidence--not just for a matter of days, but indefinitely.* As a result, it is hardly surprising that NATO improvement programs appear to be largely business as usual--important business to be sure, but not very impressive by comparison with the problems to be solved.

One reason that more convergence has not occurred is that those interested in improvements live in different professional communities with minimal communication. As a result, potential natural allies have often worked at cross purposes. Figure 3 summarizes some of these groups and their natural predilections. Although stereotyped, these characterizations are legitimate for present purposes: the groups exist (in the military services and in civilian organizations), they are remarkably disjoint, and none of them seems to feel--at present--an obligation or burning desire to resolve the various problems among groups. To make things worse, there is little tradition for integrated analysis of air and land issues (although the climate exists for doing so). If there is to be a period of convergence, there will have to be some unprecedented cross-cultural efforts. More on this later.

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<sup>2</sup>Two examples stand out: the buildup from virtually nothing of an operational capability to deter or deal with a Soviet invasion of the Persian Gulf (see Davis, 1982a, for an account of what made that buildup possible), and the buildup of the U.S. Navy under Navy Secretary John Lehman.

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**Policymakers:** concerned primarily about excessive reliance on the nuclear deterrent, about obtaining adequate budget levels for defense, and about peacetime alliance cohesion; language: forward defense, flexible response, reestablishing deterrence; models: primarily, those of the program analysts or the bean-counting models of balance assessments

**Program Analysts:** concerned with making reasonable resources available to military commanders; language: force ratios and FLOT locations versus time, mobility forces, prepositioning programs, days of supply in theater, programs for improving the survivability of air bases; models: stereotyped attrition warfare under a few short-war scenarios differing primarily in warning time

**Military Historians and Strategists:** concerned with grand strategy and operational strategy in conflict; language: maneuver warfare, daring thrusts, breakthroughs, attacks on rear-area targets, cohesion, quality, initiative, possibility of stalemates or protracted wars requiring national mobilization, surprise attack; models: none (partial exceptions: Dupuy's QJM model and some manual games)

**Simulation Modelers:** concerned with modeling selected phenomena of an idealized war (while deferring other phenomena to later studies) and adding complexity; language: data bases, subroutines, Lanchester equations; models: many, at several levels of detail further distinguishing among cultures (strategic-level, theater-level, corps-level, battalion-level, and weapons-level)

**Technologists:** concerned with finding ways to solve problems with modern technology weapons; language: PGMs, cluster munitions, sensors, fusion, centralized C<sup>3</sup>I, capability multipliers; models: many, almost always at the weapon vs. target level

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Fig. 3 -- Distinguishable analytic communities interested in conventional defense

## THE ROLE OF ANALYSIS IN ACHIEVING CONVERGENCE

With this background, then, the present paper is concerned not with the full range of issues raised, but with the potential role of quantitative (or at least formal) analysis. It seems appropriate at the outset to ask why one might expect there to be *any* role. After all, if the problems stem from economics, politics, and the short-sightedness of democracies with regard to defense, then what can analysis really contribute? First, some general observations:

- Problem solving occurs when people believe the problems are solvable (even if with difficulty)
- Analytic models and balance assessments affect what comes to be conventional wisdom about the seriousness and solvability of military problems
- When there have been periods of rapid and focused progress in solving defense problems or fielding new capabilities, there has often been strong analysis behind the effort--analysis that could be explained at several levels of sophistication and communicated all the way from the top leadership to the officers in the field<sup>3</sup>

Second, consider two of this paper's premises:

- Some of the most important problems in NATO's defense posture have to do with operational issues that cannot easily be understood and explained without analytic models
- If convergence is to occur on such complex issues as the interrelationship of conventional and nuclear capabilities, the air-land battle, the role of effective but expensive munitions, and the complementarity of what are now seen as opposing operational strategies, there must be an analytic framework within which to have the associated debate; otherwise, we shall continue to see competing essays and a failure of proponents to make their ideas "stick" when it comes time--not just once, but continually over a period of years--to convince policymakers, budgeteers, and bureaucracies

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<sup>3</sup>Examples here include U.S. programs to improve strategic mobility, basing, and support capabilities for the CENTCOM mission in Southwest Asia.

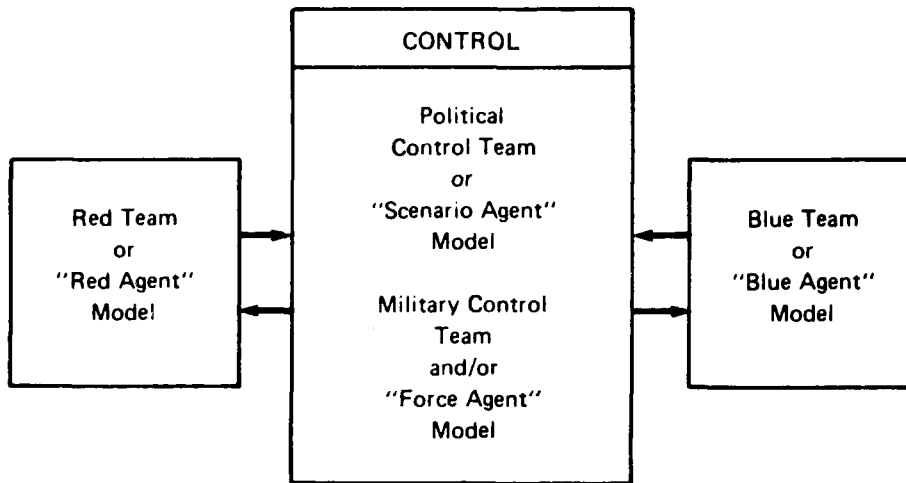


Fig. 5 -- Man-machine relationships in Rand's automated war gaming

3. The analytic war plans contain rules calling for reconsideration of concepts when events arise for which the plans were not designed (e.g., opponent escalation). When these rules, or "bounds," are triggered, it is time for special national-command-level models (or human teams) to decide whether to pick new plans, modify the current ones, or continue the new plans without change.
4. The Force Agent is a large simulation model with a global strategic-level view. In Europe, the Force Agent's resolution is basically that of a theater commander rather than, for example, a corps commander. The various component models are extremely parametric and interactive to permit the analyst or human teams to explore changes in strategy or changes in analytic assumptions.
5. It is possible for humans to work with the whole system or with particular portions of special interest. So, for example, there is a *Force Standalone* capability allowing analysts or human teams to focus on "sandtabling" (with some expert-system models for certain command-control functions); there is also a capability to build or modify new analytic war plans to be tested against the automated opponent; and there is a capability to bypass the simulations of combat and third-country decisions while focusing on the decision rules of the national command level models.

developing an analytic framework for studying NATO's options. Before discussing this, let us first review some of the RSAC's characteristic features.

### Automated War Gaming

Because of precisely the same problems discussed previously (e.g., the poverty of bean-count "analysis" and the need for analysts to address issues of command-control and interconnections among the elements of combined arms forces), the DoD concluded in 1979 that the new methods of strategic analysis should combine the best features of human war gaming and analytic modeling (Marshall, 1982). From war gaming would come the strategic perspective, the interrelationships, the richness of context, and the asymmetries between West and East; from analytic modeling would come rigor, reproducibility, and the capability to draw conclusions reasonably.

In taking on this challenge, Rand concluded early that it was necessary to *automate* the war game (Fig. 5) to gain control over the many variables (Graubard and Builder, 1982). This meant building not only flexible and efficient combat models, but also building decision models to represent the various nations. Note in Fig. 5 that humans can play at any position (Red, Blue, or Control) or can use the system as a closed simulation model with which to do experiments. Both open and closed modes are important.

The essential features of the RSAC's conceptual approach can be summarized as follows (Davis, 1984, and Davis, forthcoming), starting with the description of fully automated play:

1. The structure is roughly that of a two-player game (Red = Soviet Union/Warsaw Pact; Blue = U.S./NATO), but with modeling of *political* decisions by *all* relevant countries. All decision models are "parametric," allowing for alternative decision patterns.
2. At any time in the war game, each side is following an *analytic war plan*, which represents to some degree the features of real-world war plans *plus* the adaptations made by military commanders as the scenario unfolds. The plans are adapted and executed in a hierarchical process related to command structure.



## Interactivity

Finally, let me mention a requirement that makes far more sense in today's world than the world of ten or fifteen years ago. Recall the assertion that a major problem in the use of complex models is that they have been inaccessible to policymakers and their aides. The answer must be greater interactiveness--for both an admiral's tests and routine analysis. Flexibility is of little value if answering a "What if?" question requires hours by a group in another building. *Ideally, the response should come in seconds, but certainly in a matter of minutes--i.e., within a cognitive cycle.* All of this implies speed and efficiency.

Interactiveness also means having what computer scientists sometimes call a "friendly interface." That is, the outputs should be natural and have almost self-evident meanings. In particular, it should not be necessary to wade through computer printout to hand-draw curves or fill out tables.

## THE RAND STRATEGY ASSESSMENT CENTER

### Background

The requirements levied in the previous subsection have a deliberately close relationship with those stated by the Department of Defense in 1979 in its search for fundamentally new concepts and capabilities in strategic analysis. After a series of committee efforts, competitions, and proposals, there emerged in 1980 an effort imbedded in the Rand Strategy Assessment Center (RSAC). Although originally focused almost exclusively on nuclear issues, the RSAC's work has come to be as relevant to global military planning in general as to nuclear planning in particular--primarily because one of the biggest challenges was to develop the capability to follow scenarios from beginning to end, with considerable attention on events during conventional phases of what might become general nuclear war.<sup>5</sup> Many of the RSAC's paradigms and structures appear relevant to the problem of

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<sup>5</sup>For the RSAC's general objectives and history, see Davis and Winnefeld (1983), a report written before the current development work. See also Davis (forthcoming), Davis (1984), and Davis and Stan (1984).

## Flexibility and Ability to Address Soft Issues

Extremely important in any model framework purporting to be the basis for integration and synthesis is the capability to consider a wide range of assumptions--to respond to queries about "But what if ...?" Without this capability there would be no way to achieve the convergence discussed earlier: individuals could continue to wander off saying "Yes, but they didn't consider ...." One subtlety is worth noting here: it is not sufficient for the clever modeler-analyst to wave his hands and say "Yes, but that washes out"--even if it is trivially obvious (to him). The point will not be communicated and made to stick unless the models have knobs and switches allowing others to test the assertion directly. In practice, moreover, the "clever" modeler-analyst has often been wrong on such matters.

Examples of "what if?" questions are legion and involve many "soft" issues. Military historians, for instance, regularly deride modeler-analysts for their failure to account for differences in the *quality* of different national forces, the Arabs and Israelis being the most obvious example, and for their failure to account for effects such as surprise, the chaos resulting from having been attacked in the rear, "Fog of War," and "Friction" (Dupuy, 1979).

Responding to such requirements is not so difficult technically as it is paradigmatically. Many modeler-analysts have an emotional reluctance to treat issues that do not lend themselves well to quantification or algorithmic solutions. They also have good arguments. After all, they point out, it is one thing to create a new parameter, but who is going to provide the parameter value? The other traditional concern is that along with flexibility come more degrees of freedom and the *curse of dimensionality* when it comes time to sensitivity analysis. Such concerns are valid, but *if models of combat are to be more relevant and credible they must reflect both soft and hard issues.*

### **Reflecting National Doctrines and Propensities**

In attempting to treat political as well as military issues it is essential to be concerned with the asymmetries between the Western and Soviet views of almost everything. This can be overdone because Soviet doctrine is written for an "ideal war" very different from that we would regard plausible (e.g., the Soviet doctrine tends to assume a context of aggression by NATO under circumstances where a fight to the finish is inevitable). Nonetheless, it is ignored at our peril, since Soviet concepts of warfighting differ markedly from the image implicit in most Western combat models, and Soviet concepts of escalation control tend to be dangerously dissonant with those of NATO (see, for example, Davis and Stan, 1984).

### **Transparency and Comprehensibility**

As noted earlier, any modeling framework should be as transparent and comprehensible as possible (I distinguish transparency of a particular algorithm or rule from comprehensibility of an overall model). There is little here to engender quarrels--only when one asks what these terms mean will there be arguments, as one discovers that what is transparent to one person is opaque to another; and, indeed, what is top-down to modelers and programmers is often bottom-up or sideways-in to a strategist.

What then does the requirement mean? It means, for example, that one can find where all the important issues are treated (good modularity). Less trivially, it means that the various modules are the "right ones"--i.e., that the model's parts (and names) correspond with the objects of the strategist's attention. Also, of course, it means that one can find the important data, properly formatted and maintained in terms understandable to the strategist. It may also mean that key elements of the computer code itself are understandable to people with only modest programming skills.

It is apparent that declaratory policy is often just that, a product of peacetime pressures and compromise as much as strategy. The traditional program planner's point of view is often more nearly to the point, but not very rich. If we seek something more profound, we should take the viewpoint of force *employment* to uncover problems and solutions going beyond "more is better." Only in this way can we hope to bring together in one framework specialists from the military, technological, and resource allocation worlds. Why? Because only here is there enough specificity, depth, and military content to provide the tangible examples that are the stuff of integration across cultures.

### A Strategic Perspective

There is at the same time a conflicting requirement. If the framework is to be relevant to *strategy*, it must somehow remain above the clouds--i.e., we must not lose sight of the forest among the trees. This, of course, has been the fundamental problem from the beginning of analysis: the clamor is always for more detail from those who are concerned with the pieces, but for those addressing issues of strategy, the details must *ultimately* be scrupulously suppressed except by reflecting them implicitly in more integrated concepts.

All of this is old stuff--going by the rubric of top-down analysis--and is understood by strategists and managers in all walks of life. The trick is to pull it off: if one ignores the wrong details or interrelationships, the impression at the top is seriously flawed; if one includes all the details and interrelationships, the effort sinks of its own weight. In fact, there is no general solution other than putting smart people on the task--some with interest in details, some with interest in integration, and yet others interested in the final communication of results.

### Political-Military Structure

Credibility involves more than building good combat models; it also requires addressing--in a single structure if we are to achieve integration--the more important political-military issues such as alliance cohesiveness (NATO's and the Pact's), constraints on actions, and escalation control.

### Strategic Breadth: A Global Framework

One enduring difficulty in discussing NATO defense issues is that so many problems are dealt with by separate organizations. For example, the U.S. Department of Defense has independent offices that seldom interact for strategic nuclear, theater nuclear, and conventional defense issues; similarly, NATO governments typically have different offices for different regions (Europe, South Asia, East Asia, etc.). An improved framework for strategic analysis should attempt to cut across such boundaries.

### Integrated Planning

The next issue is more controversial. In my view, *if a new analytic framework is to be unifying rather than divisive, it must start by bringing together what are sometimes referred to as (a) declaratory policy, (b) program planning, and (c) employment planning*. These terms are most familiar in strategic nuclear problems but they apply in the NATO context as well. Note, for example:

- NATO's *declaratory policy* has generally emphasized the potential use of nuclear weapons, with conventional defense being characterized more as a means for avoiding quick and easy conquest, and for providing an opportunity to reestablish deterrence should war begin, than as an end in itself.
- NATO's *defense programs*, however, have generally emphasized conventional modernization (with the exception of some highly publicized items such as the GLCM and Pershing II). The related program analysis has generally been conducted at the DoD level with simple models focused on trends in various static measures and goals for the ability to build up Armored Division Equivalents in the European theater as a function of time after mobilization. There has been minimal discussion of maneuver and operational issues, although that is beginning to change (Kugler, unpublished).
- NATO's operational commanders, by contrast, have had to concern themselves with *employing* the forces available to them. The language of force employment, especially as there has been renewed interest in maneuver warfare and a more generally active defense effort, is fundamentally different from that in either declaratory policy or programming analysis. Also--at least in theory, *operational commanders cannot, or should not, allow their thinking to be constrained by standardized planning scenarios*.

If big policy-relevant simulations are so bad, why do I even raise the issue? The answer, of course, is that I think their time is coming. Much is possible now that was not possible twenty years ago when technology was more primitive and experience more limited. In particular, complex analyses can now be controlled better and presented more clearly. Moreover, *the more complex models are essential to our understanding of the phenomenology of war*--and the associated analysis of defense options. Figure 4 cites some examples of problem areas for which the truly simple models (and *current* complex models) are not adequate.

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o Command and control	o Responses to operational maneuver groups and early breakthroughs
-- technical (e.g., situation assessment)	
-- operational (e.g., air-land coordination and cross-national maneuver)	o Interrelationship of conventional and nuclear planning
o Logistics (including cross-national problems and implications of interdiction)	o Multitheater conflict under a range of scenarios
o High-technology weapons	o Deterrence and escalation control once conflict has begun
o Employment options for airpower	o Alternative operational strategies (e.g., mobile defenses)
o Barrier defenses	

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Fig. 4 -- Representative subject areas for which more complex models and games are needed

## REQUIREMENTS FOR A NEW ANALYTIC FRAMEWORK

Let us now turn to the future: What kind of framework is needed to go beyond where we now stand? Clearly, there will be a role for both simple and complex models, but let us focus primarily on the latter. What characteristics should they have?

credibility among those familiar with details. A common impression is that the complexity of simulations does not help. Ultimately, model results are still driven by *assumptions* about: (a) which forces are counted; (b) buildup rates; (c) the scores given to each force (a function of equipment quality and quantity); (d) various attrition rates (by killer-victim pair, reflecting weapon capabilities); and (e) the rates of advance. There are really two points here: first, it often seems that the simulations are not really adding anything of first-order importance; and second, the simulations often seem to bury key assumptions.

There are other problems as well: most combat simulations have been perceived to be (a) opaque; (b) unmaintainable (everyone has seen results that had to be withdrawn because some deeply buried data element was wrong); (c) slow; and (d) anti-intellectual by virtue of their opacity. Modeling organizations have not generally been eager to participate in detailed comparisons of models and assumptions.

I mention item (d) because senior officials tend to believe that most problems can be understood with a few variables, and to ask how outcomes change with those variables. Answering them is often more successful with simple models and graphs than with piles of computer output and grimaces in reaction to questions.

Finally, let me mention a drawback of the complex models that may in some respects be the most compelling of all: they are "beyond touch"--not only is it impossible for a policymaker to get into them personally, it is often impossible for his aides to do so. The complex models are in the province of contractors or separate agencies and are simply too far away and inscrutable to be trusted.<sup>4</sup>

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<sup>4</sup>There are some exceptions to this in strategic nuclear analysis and strategic mobility analysis. In both cases, the Office of the Secretary of Defense and the Office of the Joint Chiefs of Staff routinely use complex in-house models. However, there are special circumstances. The quality of analysis is high in both areas--with the analytic assumptions being generally understood by a considerable community. Also, both subjects are in many respects more intuitively understandable, and even simpler, than theater warfare. Thus, policymakers can feel they understand what the models are doing even if the details of number crunching are obscure.

from ten-second news spots reflecting defense reports and other studies of the "bean-count" variety.

Interestingly enough, the most expert producers of balance studies are less than enthusiastic about the state of the art. Indeed, more than anyone else they have argued for more intellectually respectable analysis (see, for example, Marshall, 1982). Nonetheless, it is likely we shall continue to see bean-count comparisons indefinitely--they have a place, they do convey some information, and they are simple. Unfortunately, they also lend themselves to simplistic thinking and tend to focus attention *too exclusively* on objects such as tanks or ICBMs rather than on more complex matters such as flexibility and command-control.<sup>3</sup>

#### THE ROLE OF MORE COMPLEX MODELS

Complexity is a matter of degree and a matter for the eyes of the beholder to discern. Here, however, I shall consider models to be either simple or complex, with simple models being those discussed above. By complex models I shall mean the full range of models for which computers are needed. Later, I shall introduce some distinctions.

Given the many years of experience with combat simulation models, one might expect that such models would have had a significant impact on policymaking. I would argue, however, that simulations of NATO/Pact conflict have had very little influence on policymakers (although they have certainly affected logistics, weapon-level, and doctrinal planning within the individual military services. The point is arguable, but I will assert that I have *seldom* heard a senior or mid-level official of the U.S. government base policy-level conclusions on the results of a theater combat simulation. To the contrary, I have *often* heard such simulations derided and arguments based on them dismissed out of hand.

The reasons for this lack of influence are many and varied. The most fundamental reason is that the combat simulations lack *credibility* among experienced policymakers, just as the simpler models lack

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<sup>3</sup>Blaker and Hamilton (1977), themselves well experienced in balance assessments, predicted some seven years ago that the U.S. Congress would begin to hear more about these matters and less about bean counts. That prediction seems to have been premature but was certainly in the same spirit as the present paper's suggestions.



- They lack *credibility* among those who rightly expect that there "must" be more to the balance than theater force ratio and those who note that the simple models have not been "validated" as approximations to more complex treatments
- Because they are so aggregated, they have no potential for unifying such disparate communities as the technologists, historians, maneuver warfare advocates, and resource managers
- They have little to say about matters of command and control, military organization, and the doctrines behind decisions
- Finally, they often fail to convey a sense of interrelationships and provide only a modest sense of operational strategy<sup>2</sup>

It follows, then, that there is need for a more profound analytic framework than is possible with the simple models. The search for such a framework has begun but will not be completed soon.

#### BALANCE COMPARISONS BY BEAN COUNTS

There is another form of simple analysis that is usually associated with the name "static measures" (or, less formally, "bean counts"). Over the last two decades, the effort to count weapons and divisions and to deal in other miscellaneous static measures has become somewhat of a cottage industry. There must be a dozen organizations in Washington alone that consider themselves as doing analysis because they can generate bar charts displaying such comparisons. Such "analyses" have had a profound effect on the thinking of the American man in the street, albeit indirectly. The vague impression that slowly turns into a conviction that more money should be spent on defense, and that more should be done to modernize our forces, comes in significant measure

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<sup>2</sup>The problem here is not the authors but the medium: the effort to reduce issues to an analytic framework oriented toward resource allocation tends to produce a cold product, with the richness of strategic thinking to be found only in the essays that accompany the quantitative analysis (see, for example, Kaufmann, 1983). The essays, however, tend often to be brief and subjective. Furthermore, the linear nature of essays makes it difficult for readers properly to integrate their content. This is why human war games have had so much effect on many peoples' thinking: they have the right format, including a sense of drama, to exploit uniquely human capabilities for integration (e.g., capabilities to learn from argumentation and debate).

- High-leverage measures include: (a) maintaining European reserves at a high state of readiness; (b) prepositioning equipment for U.S. forces so that fully equipped divisions would be available as quickly as the men could be flown in from the CONUS (POMCUS programs); (c) starting NATO mobilization early; and (d) obtaining substantial early French participation

In their simplest form, these arguments require little more in the way of modeling than a method for normalizing divisions to a standard measure (e.g., Armored Division Equivalents, ADE) and a model for predicting the rates at which various forces can be mobilized and deployed to the front. Such "models" can be back-of-the-envelope constructs plus some data tables.

*These simple models have been influential because they are understandable, dealing with issues at only the most aggregated of levels.* Also, the principal conclusions drawn from these models have been almost obviously valid: strategic mobility is good; rapid mobilization is good; operational reserves are good; and providing divisions in Europe with substantial firepower and mobility is good (although overemphasis on ADE score alone has been a chronic problem in cost-effectiveness studies, especially those involving combat in mountains, forests, and urban areas).

Users of the simple models have also had an impact on notions about what is *feasible*. It is difficult to read papers by such an experienced figure as William Kaufmann and not conclude that in theory the resources are there for NATO to be successful--the issue is how and with what efficiency we *allocate* those resources (dollars, manpower, etc.)--and how well our generals use them. That is, one can argue that the problem is one of outputs rather than inputs. This is especially so now with the sustained real growth in U.S. defense budgets.

In summary, there is much to applaud about simple transparent models. Moreover, they have been and will continue to be the first line of advocacy and analysis. Nonetheless, it seems to me that the simple models have already accomplished what they can--although continual reminders of their lessons are necessary. The serious problems preventing the convergence discussed above cannot be solved by analysis with simple models because:

## II. FRAMEWORK PROBLEMS FOR CURRENT ANALYSIS

### THE ROLE OF SIMPLE MODELS

One might naively think that operations research and simulation modeling would have had an enormous impact on policy-level thinking about the military balance and appropriate Western strategies. In practice, however, it seems that the most influential quantitative analyses have been simple and essentially constant in form. So, for example, one can find similar analysis in studies by Enthoven and Smith (1971), the Congressional Budget Office (1980), Kaufmann (1983), Posen (1984), Mearsheimer (1983), Mako (1983), and unpublished work by Richard Kugler of the Department of Defense. These analyses focus on a highly aggregated view deemed appropriate to civilian planners attempting to make adequate resources available rather than attempting to assure good operational planning or clever generalship. The continuing themes of that school include:

- The NATO balance is driven by assumptions about which nations will commit forces, which forces of each nation to include, how to count forces of different quality and composition, and *timing*
- NATO's chances for success should be reasonably good for theater force ratios less than about 1.5, with force ratios of 2.0 being quite worrisome<sup>1</sup>
- The principal problem, then, is for NATO to assure that theater force ratios be kept as low as possible at all times--thus implying a need not only for forces but also for rapid mobilization and deployment

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<sup>1</sup>Roughly speaking, these rules of thumb relate to the famous 3:1 criterion of local concentration as follows: imagine, say, 40 NATO and 60 Pact divisions scattered evenly among 8 corps sectors (5 and 7.5 divisions per corps sector, respectively, for an overall ratio of 1.5). The Pact could take its excess 20 divisions and concentrate them on main axes. With, for example, 2-3 main axes, the Pact could achieve local force ratios of 2.8-3.5 if NATO failed to detect and react to the concentrations. Concentrating on a single axis would be possible in principle, but more difficult to achieve without NATO observing and concentrating its defenses quickly as well.

These, then, are the articles of faith. It remains to add some details.

Figures 6 and 7 summarize key features of the conceptual architecture, which is reflected faithfully in the system architecture. Figure 7 elaborates on part of the hierarchical structuring of military command levels. As Figure 7 indicates, the RSAC simulation is based on the U.S. point of view, so that Blue is primarily the United States and secondarily the NATO alliance.

### Program Status

The RSAC program has recently completed two years of full development activity (using some concepts and tools developed over a longer period). We now possess a *prototype* system with a wide range of capabilities. There remain many loose ends, including empty holes for undeveloped models and data bases of varying quality. Also, we have a great deal to learn about how to achieve transparency, flexibility, and all those other virtues. Nonetheless, the prototype system is a reality, applications are under way, and I can speak with some confidence about what is possible. For example:

- The decision rules are written in an English-like computer language allowing individuals with only modest knowledge of programming to understand the rules and make substantial (although constrained) changes.
- The force models can be run by a single analyst and are fast (e.g., 10 minutes on a VAX 11-780 for a 30-day European war testing sensitivity to some change in force structure or modeling parameter).
- A full-system automated war game (crisis through general nuclear war) takes about 1-2 hours.
- The National Command Level (NCL) and Scenario Agent models have proved powerful in organizing both "hard" and "soft" information and logic on national decisions. Research with NCL models has already been illuminating on how to think about deterrence and escalation control.

So much for a quick once-over of current RSAC capabilities. Let us turn next to how such techniques can be used to address issues of NATO

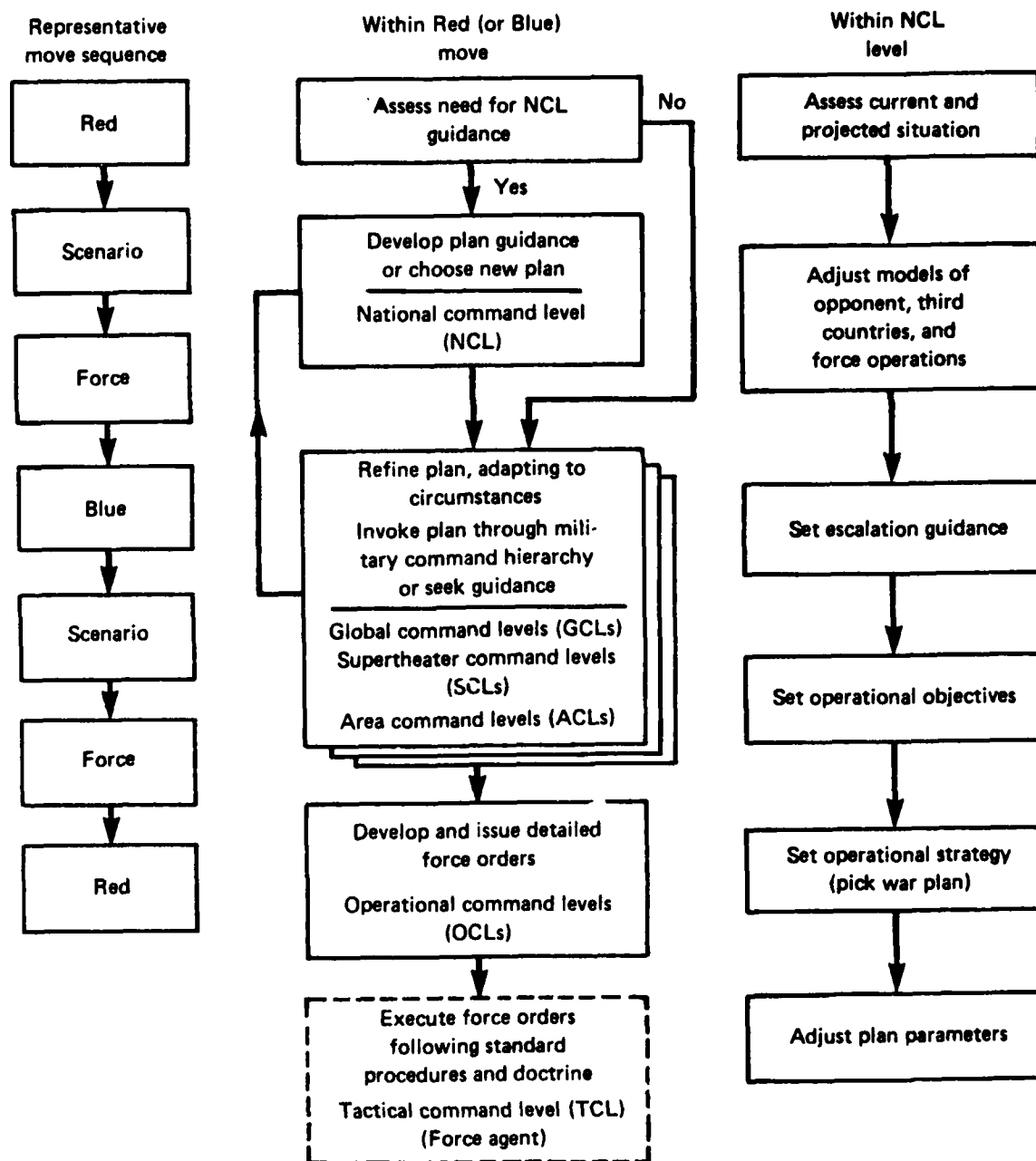


Fig. 6 -- Hierarchical view of RSAC war-game simulation

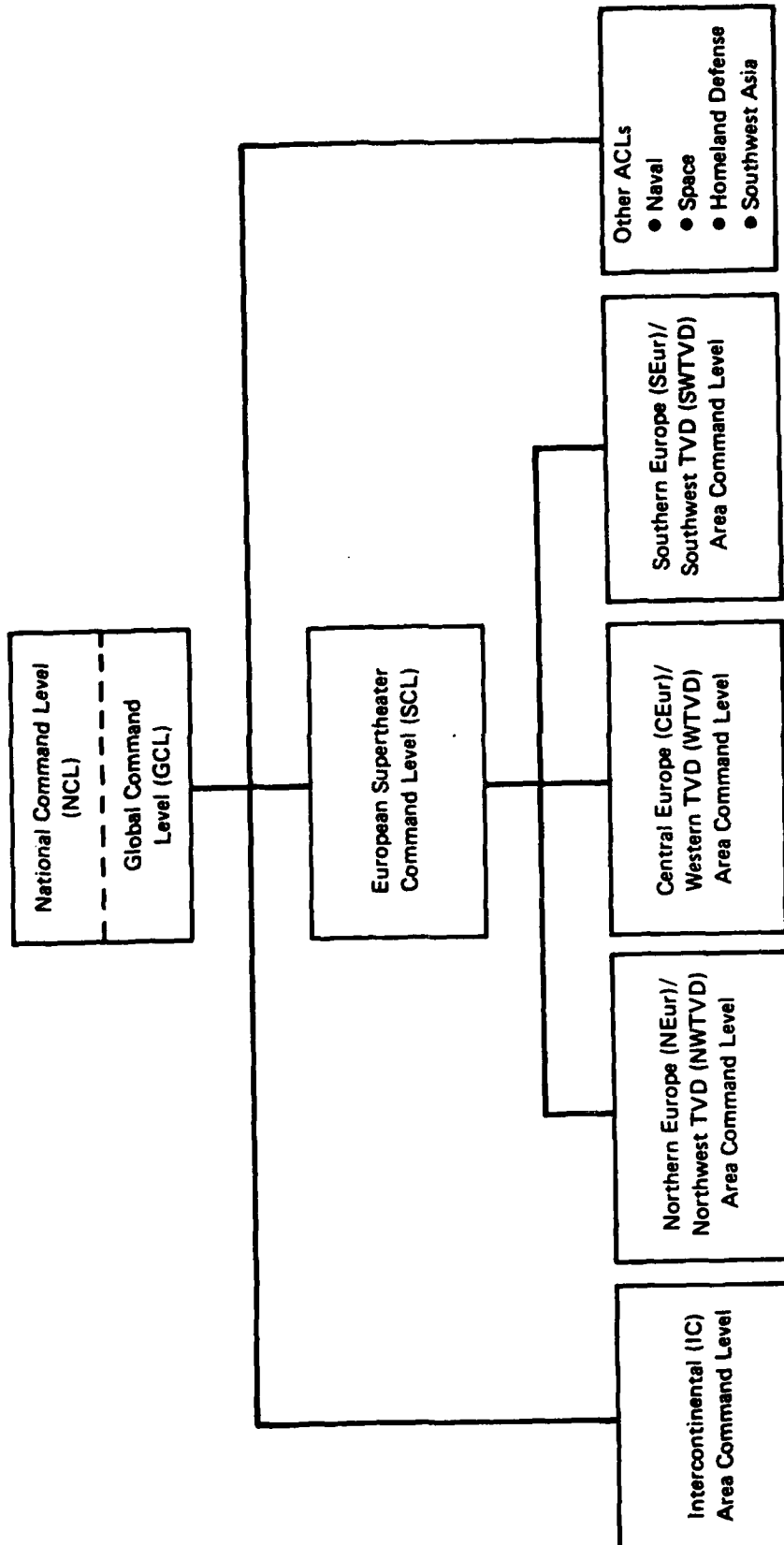


Fig. 7 -- Simplified model hierarchy within Red and Blue Agents

strategy. The next two sections deal with treatment of uncertainty in balance assessments and with developing more complex strategies. A major theme is the importance of multiscenario analysis.



### III. THE CONCEPT OF MULTISCENARIO ANALYSIS

#### DEFINITIONS

The problems with single-scenario assessments<sup>1</sup> are well known in the abstract, but we have lived with them so long it is useful to remind ourselves of their consequences (Fig. 8).

In principle, "standard scenarios" are used only for limited purposes such as developing total force requirements on a coordinated basis (e.g., with the Navy, Army, and Air Force buying munitions for the same type of war). In practice, the standard scenarios and standard planning assumptions are used for virtually everything. They even infect operations planning. Why? The reasons are many and varied but

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- o Encourages organizations and planners to focus on rigid scenarios unlikely to be seen in the real world
  - o Discourages focus on adaptation and contingency planning
  - o Conveys an excessively firm impression about the military balance--one that can be unduly pessimistic in some respects while being unduly optimistic in others (i.e., creates bad intuition)
  - o Discourages certain types of initiative and daring actions (e.g., avoidance of battle at moderately adverse force ratios; excessive emphasis on static tactics)
  - o Tends to submerge important but non-best-estimate possibilities (e.g., early breakthroughs or the catastrophic failure of some weapon system)
  - o Provides little useful to operational commanders, who tend to look elsewhere (e.g., to intuition) for assistance
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Fig. 8 -- Side effects of single-scenario analysis

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<sup>1</sup>In this paper I consider multiscenario analysis to include variations in context, timelines, forces, strategies, and technical parameters--not merely basic timelines. A better terminology might be uncertainty analysis.

start with the desire in large organizations to avoid friction by following conventional procedures.

Many people would rightly argue that these problems have always been recognized and that even the fathers of system analysis emphasized the need to conduct multiple scenarios (see, for example, Madansky, 1968). However, this is all a matter of degree. For example, many articles treating a wide range of NATO defense scenarios turn out ultimately to be varying only warning time. Admittedly, warning time is a big issue, but if one wants to get in the spirit of adaptive thinking and into a mode of appreciating problems of command-control and flexibility more generally, there are many other uncertainties, such as those in Fig. 9. To elaborate on just one example--grand strategy--should not NATO's conventional-defense strategy at the time of conflict depend on whether the Pact is apparently seeking a short war for limited gains or a war of indefinite length for ultimate aims? It is this type of issue that leads me to emphasize the need for complex and adaptive strategies.

Unfortunately, so long as analysts limit themselves to back-of-the-envelope calculations or to large and ponderous detailed models (e.g., weapons-level models designed primarily for use by the individual military services), it will be impossible to examine any great range of

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o Initiating political-military scenario	o Operational-level strategies
-- context	o Technical assumptions about "laws" of combat
-- alliances	
-- timing of events worldwide	o Qualities of forces by nationality, unit, and region
o National temperaments and grand strategies	o Effectiveness of various weapon systems and tactics
o Military strategies	o Rolls of the dice in regard to particular battle outcomes, etc.
o Force structures	

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Fig. 9 -- Representative classes of uncertainty

the variables in Fig. 9 intelligently. The result will be to maintain the schisms between classes of analysts.

Why is this so terrible? Because, for example:

- Standard NATO balance assessments provide a sense of doom and gloom even though the uncertainties involved suggest that NATO *might* actually do well were the Soviets to attempt a conventional invasion, even today (i.e, the attitude should be one of a distinct underdog, but with a significant chance of success).
- There are in fact many classes of plausible scenarios, some of them favorable to NATO and--as we all recognize--many that are quite worrisome. The trick, in part, should be to create a mind-set that NATO is not a passive actor--that with appropriate actions it can control to a considerable extent the scenario and the likelihood of successful defense.
- The opening days of a real conflict would probably bring some dramatic surprises: e.g., tactics or weapons that work or do not work. Without prior thought about how to adapt--exploiting opportunities as well as coping with problems--opportunities will be lost, the initiative sacrificed, and, quite possibly, the war lost.
- The single-scenario approach and its usual variants obscure many of the problems that would be most dangerous to NATO should war occur--problems of flexibility, reaction time, surprise failures of particular systems or forces, and cross-national operations, all of which tend to be assumed away in ordinary studies.

## PRINCIPLES OF UNCERTAINTY ANALYSIS

Now that we are gaining some experience with multiscenario analysis, we are beginning also to formulate principles. Some of them will look familiar to system analysts with careers dating back to the 1960s or earlier. Figure 10 lists the principles I currently urge on my colleagues.

Let me comment upon only a few items from Fig. 10. First, the matter of looking for the good as well as the bad. The point here is not to obscure miserable features of the current military balance in Europe--I am sure that most readers are in no mood for that in 1984. Rather, the point is that if we are to be good competitors in peacetime and successful warriors should conflict occur, it is essential that we

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Philosophy	<ul style="list-style-type: none"><li>o Use complex measures relevant to commanders in preference to "analyst measures of effectiveness (MOEs)" (e.g., use maps or graphs in terms of variables the commander can control, charts showing critical windows in time)</li><li>o Examine <i>all</i> classes of uncertainty, both hard and soft, then filter</li><li>o Look for good cases as well as bad; seek opportunities as well as disaster</li><li>o Consider less-than-optimal opponent (and own) actions as well as ideal responses</li><li>o Remember objectives: improve odds, hedge bets, exploit opponent's problems, identify high-leverage measures</li><li>o Reflect actual operational considerations rather than analytic simplifications</li></ul>
Techniques	<ul style="list-style-type: none"><li>o Eschew mechanical one-variable-at-a-time sensitivity testing, since correlations and analytic aggregations are important</li><li>o Ultimately, focus on "cases" and alternative paths to them</li><li>o Use multiple baselines, since model sensitivities are often sensitive to the baseline assumed</li><li>o Resist the allure of Monte Carlo techniques or more detail</li></ul>

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Fig. 10 -- Principles of uncertainty analysis

know where our opportunities lie. It is striking in this regard to speak with Israeli general officers about their contemptuous views of Soviet doctrine--not just as practiced by Arab forces, but as formulated by Soviets for Soviets. On the other hand, I am less impressed with the much-vaunted Western capability for innovativeness when I realize that contingency planning across a broad range of war situations is not a basic part of Western military training.

The second point I will touch upon briefly pertains to the last item, that about Monte Carlo analysis and the addition of detail. In our experience at Rand, it has been a constant effort to maintain comprehensibility in our force models: the pressure has almost invariably been to add details (but only details of interest to the particular suggester); and, from many analysts, to add Monte Carlo features. With respect to the former, I can only assert that it is extremely difficult to maintain comprehensibility, and that once that is lost, everything is lost. Furthermore, there are straightforward analytic tests to see whether certain details are worth inserting--with the answers dependent, of course, on the problems of interest. Merely because modelers love to include new phenomena, which they insist are "important," does not make the phenomena important for the purposes at hand; nor does it mean that the phenomena cannot be reflected adequately by some simple relationships.

With respect to Monte Carlo analysis, which can be extremely valuable when properly conducted, my experience has been that relatively few Monte Carlo models are exercised long enough to produce valid results. There is even a marvelous term, "one-pass Monte Carlo," that refers to the practice of using the model with precisely one sampling of all the random variables. It seems to me that the users of such models are either doing their sponsors a disservice or fudging the distribution functions to assure that the one sample will give something close to the expected value. In a war game or simulation as complex as the RSAC's, it is hopeless to think of extensive probabilistic analysis *except* on specific issues. And, indeed, we intend *sometimes* to insert stochastic features to treat some of those specific issues (also, to prevent human teams from being complacent about uncertainty).

Finally, a comment about the history of large-scale simulations when applied to policy problems. The most striking single observation is the number of sheer blunders that have been committed by people who became too obsessed with their simulation to step back for some thinking and consultation. Running big simulation models is *not* the same as running "experiments." It is with such examples in mind from other efforts that I urge people to avoid "mechanical" operations and sensitivity testing.

## AN ILLUSTRATIVE DISCUSSION OF MULTISCENARIO ANALYSIS IN A NATO CONTEXT

### Background

Having discussed principles, let us now consider some examples. Consider a class of wars originating in some third area such as the Persian Gulf and then spreading to Europe. Suppose further that the war remains conventional. And, just to narrow our focus even more, suppose that unlike many studies, ours are concerned with measures other than force building. What, then, might we address as part of a balance study with recommendations for correctives? Figure 11 suggests one such list.

This list is neither detailed nor comprehensive, but rather illustrative. However, note the *range* of uncertainties it mentions. Assuredly, we would want to consider different basic timelines. In addition, however, we would want to look at uncertainties about the behavior of individual Pact states, about the effectiveness of certain key weapon systems, about the fungibility of operational reserves across corps sectors in a multinational environment, about strategic and tactical surprise, and about various analytic assumptions usually buried deep within models.

### Modeling Adaptations and Scripted Models

A characteristic of multiscenario studies is that the original models never incorporate all the sensitivities we are interested in. Thus, we must modify the models. An article of philosophy here is that when we encounter a phenomenon important to strategic-level discussions we make every effort to reflect its *effects* in our simulations--whether or not the *mechanisms* of the phenomenon can be adequately modeled. So, for example, there is considerable current interest in Soviet Operational Maneuver Groups (OMGs). It is not possible at our level of aggregation to follow the actions of such units individually (we work with effective equivalent divisions labeled by nationality, strength, location, and type). Moreover, even with high-resolution models, the uncertainties attending any effort to simulate in detail the consequences of an OMG insertion would be legion. It would therefore be easy to rationalize dropping the issue altogether. However, in the

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- o The time gap between conflicts on the various fronts
  - o Pact and NATO preparations *before* formal mobilization in Europe (including development of barrier defenses during a prolonged period of cold war)
  - o Pact and NATO mobilization rates for different classes of unit
  - o Pact (and NATO) coalition problems: delays in mobilization, unenthusiastic participation, LOC problems
  - o Use and effectiveness of airpower and helicopters
  - o Stocks of "high-tech" weapons
  - o Use and effectiveness of chemicals and operational maneuver groups
  - o French participation and entry time
  - o Cross-national command-control problems
  - o Operational-level choices (e.g., Soviet decisions about the intensity of conflict; both sides' criteria for offensive operations; flank exposure)
  - o Effects of surprise and/or early breakthroughs
  - o Effects of assumptions regarding the mechanism of FLOT movement (e.g., dependence on force ratio, density, and/or attrition)
- 

Fig. 11 -- Illustrative sensitivities to be addressed in a NATO balance study for fixed force levels and weapon capabilities

spirit of human war gaming and consistent with an overall philosophy, we instead build a *scripted model* (Davis, 1982) by asking:

- If OMGs were used successfully, what would the results look like at the level of resolution of our model? That is, we do not "see" rear-area disruption, but if it occurred, what would be the consequences for the variables we do follow?
- If OMGs were used unsuccessfully, what would the results look like?

- To first order, what are the circumstances under which OMGs might plausibly be used with some likelihood of success, and what are the circumstances under which we might expect them to be largely annihilated if used?

The scripted model, then, incorporates the answers to these questions and a switch: if the analyst wants to see the effect of OMGs in a particular game, he can turn the switch on. In some instances he will see a marked (upper-bound) effect; in others, none at all--depending on circumstances such as the availability of operational reserves and NATO close air support sorties. Now, obviously, this form of analysis is limited--and it is not unusual for people to react negatively to the concept of scripted models. However, the rejoinder is also obvious: Is it better to leave out discussion altogether? No, it is not. The next question is whether there is any content to the answer: Is one not seeing only what one put in? Here, of course, the answer is yes--but with qualifications. After all, *any* deterministic simulation produces only what was put in. The point is that a complex simulation model keeps track of interrelationships and dynamic changes that no individual can consistently keep correctly in mind, even if he made all the initial assumptions. Thus, in practice, good simulations--including those with "scripted models"--often produce results that initially seem surprising, even though in retrospect they appear perfectly intuitive and even trivial.

Another example involves the problem of *early* Pact breakthroughs. Virtually all analytic models preclude seeing such a phenomenon because movements of the FLOT and attrition are driven by force ratios (or by something similar but more sophisticated such as the potential-antipotential calculations). So long as NATO has mobilized to some degree, the force ratios are not generally bad enough to permit--in the analytic models--an early breakthrough. Hence, the problem goes away. But the problem does not *really* go away because Pact doctrine indicates they will go to extraordinary lengths to achieve such breakthroughs and history indicates that there is enough uncertainty about results of individual battles that we should expect the Soviets to be successful in some. And here is the wrinkle: if we operate usual models with the



usual assumptions, the FLOT never breaks until NATO has lost by best-estimate attrition; by contrast, in the real world an early breakthrough *might* result in massive NATO attrition due to breakthrough forces getting into the rear of NATO forces still on the front, with a loss of NATO cohesion and effectiveness. Such effects are simply not captured in axis-of-advance models without special efforts.

If we take the scripted model approach, what do we do? First, we ask some questions:

- Under what circumstances would breakthroughs not predicted by the baseline model be reasonably likely in the real world? (Answer: this is in large part a function of defensive *density* and of competence, surprise, technical uncertainties, and the availability of defensive airpower)
- If a breakthrough occurred, more or less as the Soviets expect, what would be the consequences at our level of resolution? (Here the answer involves greater-than-nominal NATO attrition in the breakthrough axis, and, perhaps, adjacent axes, and a rapidly moving FLOT)
- Under what circumstances would the breakthrough be likely to bog down for reasons other than those covered automatically by the standard model bringing up operational reserves to confront the breakthrough forces? (Examples of such circumstances might include NATO air superiority and delays in the exploitation phase due to logistics problems.)

Armed with some nominal answers and variable parameters to reflect uncertainties, we could again build a scripted model and perform excursions. One value of this exercise would be to estimate the effects that a breakthrough would have to achieve before it would indeed be a catastrophic event for the defense rather than "business as usual in warfare." We should remember, after all, that the assumptions used in all aggregated models having to do with rates of advance and attrition implicitly average over a range of phenomena that include local breakthroughs and local responses by the defense.

Another virtue of this approach is that it suggests a new measure of effectiveness: performance of the defense given the *assumption* (i.e., prescription) of a breakthrough. How one accomplishes this "prescription" should reflect detailed analyses emerging from war games with human teams and a maneuver-level "board." On the other hand, the

results will be predictable and desirable: they will highlight the importance of having early operational reserves that can reliably and efficiently be used on the axes in question (a function of unit locations, experience in rapid maneuver, nationalities, command-control, and experience with cross-national reinforcement operations).

These examples should be sufficient to indicate our general approach. Figure 12 lists some of the model adaptations we have had to make in recent work of this general nature.

### Speculation About Possible Results of Multiscenario Balance Assessment

Although it is always dangerous to do so, I would speculate that the results of such a balance assessment would include the following conclusions:

- NATO can defend successfully in many plausible cases--at least for a period of weeks, and *possibly* much longer (a function both of sustainability and of Soviet willingness to commit strategic reserves). In many other plausible cases the Pact could conquer the FRG and, in some cases, most of Western Europe
- Any public image of an *easy or certain* Pact victory is unduly pessimistic, unless one assumes that NATO policymakers will be stupid (e.g., slow to respond), that NATO forces are inferior in quality, or that NATO generals will be incompetent<sup>2</sup>
- Many measures are available to NATO that would exploit uncertainties and diminish any Soviet confidence in victory
- Stalemate leading to a "WWI model" is a distinct possibility--with implications for sustainability
- War outcomes could be quite sensitive to *early* availability of operational reserves and to cross-national command-control (also, of course, to warning time!)

On the basis of sensitivity analyses already performed I can also assure you, with no surprise expected, that war outcomes are sensitive to all the issues in Fig. 12. Analyses involving nuclear conflict are even more complex and uncertain.

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<sup>2</sup>My intention here is not to express optimism--current NATO deficiencies are very worrisome--but rather to underline the great uncertainties about outcome suggested by analysis.

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- o Sensitivity to different assumptions about readiness and training of lower-quality units
  - o Scripted models for OMGs and breakthrough operations
  - o Options to build barriers and prepared defenses over time
  - o Nation-specific sensitivity to supplies
  - o Nation-specific mobilization rates and effectivenesses for Pact (and NATO)
  - o Asymmetric treatment of NATO and Pact attrition, reflecting differences in repair doctrine
  - o Expert-system reallocation of ground and air forces according to an operational strategy rather than an optimizing algorithm ignoring constraints
- 

Fig. 12 -- Representative model adaptations

## COPING WITH THE RESULTS OF MULTISCENARIO ANALYSIS

In previous times models were sufficiently ponderous that we did not worry particularly about multiscenario analysis. That era, however, is behind us. We now have the capability to produce far more simulations than we are prepared to analyze, so new techniques are essential.

So far, we have only begun to cope with this problem. One can talk about postprocessors and the like, but a substantial part of the problem is conceptual: how do you examine many simulations quickly, and how do you portray the results? Eventually, I suspect that we will show results in the form of distributions over ordinally ranked war outcomes, with alternative rankings and alternative measures of outcome. I suspect also that an important measure of effectiveness will be the flexibility--i.e., the options--enjoyed by the NATO commander during the course of the simulated war.

In the meantime, we (and others such as the Blumenthal group at Lawrence Livermore and parts of the Army's Concepts Analysis Agency) have made substantial progress in one area. We have made a significant

investment in *graphics-oriented analytic outputs*--partly to make the results more understandable to senior officials and officers unable to spend much time on the issue, but partly because of empirical evidence that man-machine interaction is also greatly enhanced for the *analyst*. Some will always prefer tables, but for pure efficiency and clarity it seems that maps and graphs are inherently superior. Figures 13 and 14 show representative displays, although hundreds of choices are possible. They are available immediately after a simulation on color-graphics monitors (recall that a 30-day European war requires about 10 minutes for an excursion). A hard-copy color print can be produced in about one minute.

There are many options for using such capabilities. For example, one can display graphs of simulation results for excursions overlaid on those for a baseline case; or, one can display results side by side. In any event, it is possible in this way to go through a great many excursions quickly, observe key sensitivities, and determine which runs warrant more careful scrutiny.

Although there is little completed multiscenario analysis as yet, *the era of fast multiscenario analysis of theater conflict is here*. This means, among other things, that *it should be possible efficiently to force convergence on many issues that have traditionally been dealt with in competing essays*. It should now be possible to challenge the advocates of alternative views to become specific enough to allow calculations, to accommodate alternative initial assumptions, and to respond quickly to the predicatable changes of assumption that will emerge after the initial analysis of results. All of this, of course, will come to nought unless the models have some credibility and address--albeit imperfectly--the phenomena at issue. Hence the fundamental importance of scripted models and the philosophy of using them regularly (Davis, 1982b).

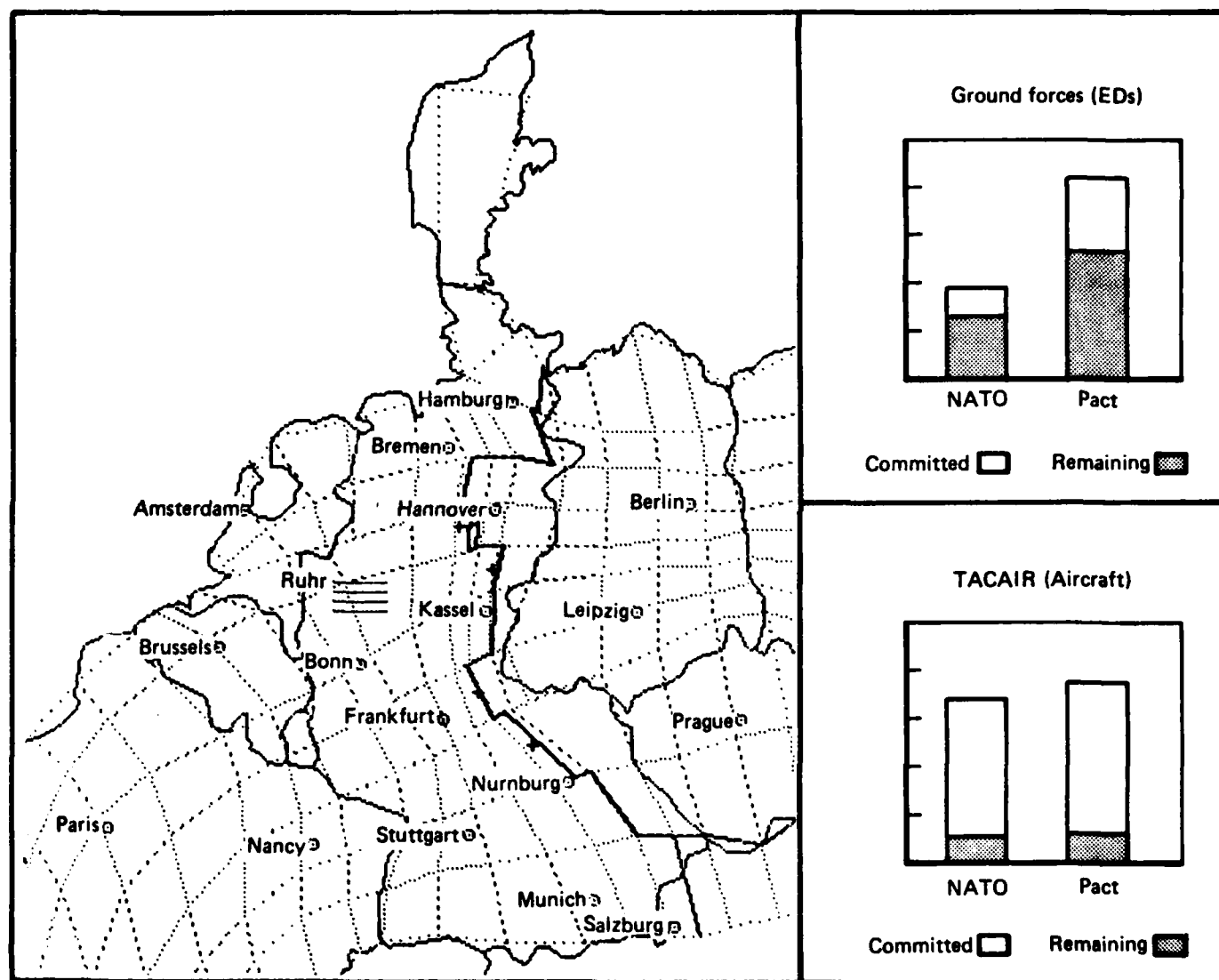
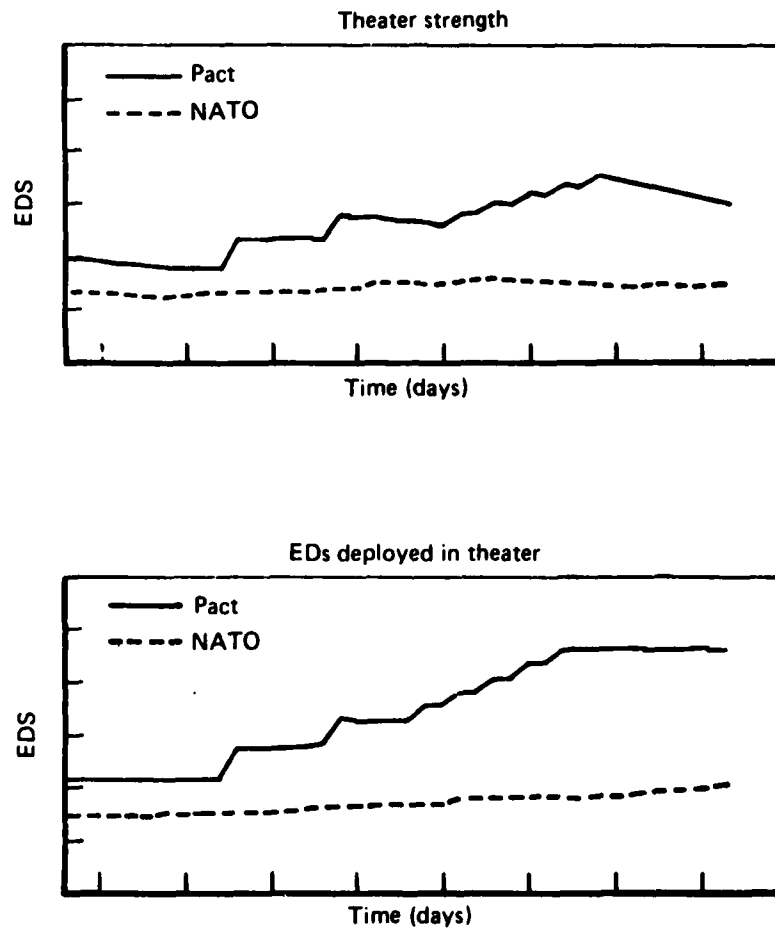


Fig. 13 -- FLOT locations in Central European theater after a period of conflict (original in color)



NOTE: ED = Equivalent division.

Fig. 14 -- Representative simulation outputs showing Pact and NATO strength over time

#### IV. COMPLEX STRATEGIES AND BASIC MILITARY MISSIONS

Let me now draw on a rather different aspect of our experience so far with game-structured research and analysis. Whereas the previous section dealt largely with combat simulations and multiscenario analysis, here I would like to discuss briefly some of what we have learned in constructing prototype automated agents and the associated analytic war plans.

##### EFFECTS OF THE GAME PARADIGM

Structuring research around the paradigm of a war game has a fundamental effect on people's thinking: it discourages simple-minded focus on optimizing algorithms and mathematically clever but militarily irrelevant models, and encourages a focus on matters global, strategic, and operational.

A second effect is that the game format encourages participants to think about ways to "win"--to frustrate the opponent's strategy and to reach an acceptable outcome. The game paradigm is very different from the more passive paradigm of bean-count comparisons.

##### AUTOMATED AGENTS

Although work in this area is still relatively primitive, prototype models exist and I am confident that it will be possible to capture in decision models a reasonable fraction of what competent human players have in mind when they participate in political-military war games. That does not mean that the models will be as smart, flexible, or innovative as the best humans--rather, it is a commentary on the limited (albeit rich) scope of political-military war games: the same issues arise over and over again, as do the same decision points.

Another interesting observation from our work in this area is that the process of building automated national-command-level models illuminates issues of deterrence and escalation control (see Davis and Stan, 1984). Unless one undercuts the whole concept by constructing stereotypical decision models rather than more plausible models

exhibiting different behavior under different circumstances (what we call "complex" Ivans and Sams), the process of developing decision rules reflecting the various national predispositions is both illuminating and worrisome. Without going into details here, let me merely say that there is a reasonable chance that *if* convergence is ever possible between those who wish to rely primarily upon nuclear deterrence and those who wish to rely primarily upon conventional deterrence (I exclude consideration of nuclear disarmers here), then that convergence might well be achieved by structured gaming with the capability for quick and easy "What if?" queries and the opportunity to test changes in controversial decision rules. Similarly, I believe there is the *potential* for closure on more complex issues of NATO's nuclear-use policy. I do not mean to imply that we now have a panacea for resolving disputes, but to express the view that much is possible because current mechanisms of debate are so crude.

#### ANALYTIC WAR PLANS

The first thing we learned in attempting to put together analytic war plans is that many people claimed that doing so would be impossible: the building-block approach, it was alleged, does not work. This viewpoint is peculiar to those experienced in conventional military analysis rather than, for example, strategic nuclear analysis. Moreover, it is most assuredly *not* the viewpoint of those most experienced in policy-level work on planning scenarios, regional balances, strategic mobility, and global war games. To the contrary, to those with such experience it seems quite plausible that a moderate number of building-block plans will provide more than enough potential for a wide variety of scenarios. There are, however, serious technical difficulties.

With that background, let me make some more pointed observations from our work so far:

- The requirement to have a war plan for every theater of the world, even if the war plan temporarily consists of nothing more than a one-line operative concept and decisions about force allocations, encourages a strategic view and sensitizes the analyst to problems faced constantly by military planners (especially U.S. planners with their worldwide responsibilities)



- The technical difficulties associated with building adaptive analytic war plans have direct parallels in real-world problems
- Developing analytic war plans is an excellent process for bringing together the cultures of military planner, intelligence specialist, and system analyst
- Allowing someone with a controversial strategy (Soviet or NATO) to have his own plans that can be tested evenhandedly is a good mechanism for encouraging creativity while revealing flaws in argumentation
- The requirement to translate vague operational concepts into formal instructions and plans is an excellent vehicle for improving communications and achieving closure among disparate groups. Often the disagreements originate in implicit assumptions about circumstance: neither group would use their concept under all circumstances, and there can even be some agreement about the circumstances under which the various concepts might be applicable. Disagreements then continue on the likelihood of those circumstances arising, but that is a different issue. In this way, for example, it is possible to turn chaotic feuding into rational discussion about when the Soviets might use airborne forces, operational maneuver groups, naval infantry, etc.

Unfortunately, none of this is yet easy to accomplish technically. It will probably be another six months or a year before the techniques for building analytic war plans efficiently and transparently are well developed.

## COMPLEX STRATEGIES

As a by-product of attempts to build plausible analytic war plans and the national command level rules for changing plans, it has become increasingly apparent that many of the nonconverging debates about NATO strategy have their origin in the implicit assumption that strategy is an either-or proposition. In reality, *an enlightened military strategy would have numerous branches--and room for considerable ad hoc adaptation.* In this regard, it seems that an ideal military strategy for NATO might well involve classic forward defense under most circumstances, but other defenses under circumstances such as a surprise attack. Moreover, there is no contradiction between forward defense with heavily mechanized units and the hedge of well-armed and trained

territorial reserves suitable for a variety of specialized defense measures in particular sectors.

Moving into more controversial areas, there is nothing contradictory between a principal reliance on conventional defense and having the operationally feasible option for *early* first nuclear use to thwart certain types of surprise attacks (as well as nuclear options to be used later in conflict as necessary). Some would say an analogy exists with the threat of nuclear decapitation of the United States in a surprise Soviet first strike. Under circumstances of such an attack it might not be surprising if the U.S. response were stereotypically massive retaliation (see comments by Harold Brown, in Brown (1983)).

### BASIC MILITARY MISSIONS

Let me now comment on what I would expect to emerge from more experience with multiscenario analysis, game-structured simulation, and development of automated agents. Basically, I would expect to see far more emphasis on mixed strategies and strategies with explicitly identified multiple components. Analysts (and policymakers) would no longer be able to characterize strategies with "one-liners." Instead, they would have to flesh out their concepts, and in the course of doing so they would identify a longer set of military missions than is usually discussed in analytic papers. These would include, for example (skipping here the usually emphasized military missions of stopping the initial Pact advance and regaining lost territory):

- Worldwide *intelligence* and the ability to integrate it properly (important in monitoring Soviet preparations for war, and, in turn, for judging the feasibility of different Soviet strategies)
- Measures for *early use of strategic warning*--i.e., in a lengthy cold war, but well before mobilization would be seriously contemplated (e.g., well-developed plans for barrier defenses, assuring adequate stocks in all corps sectors, assuring arrangements for timely coverage of forward positions, and heightened security against standing-start attacks)
- Measures for coping immediately in Europe with any *diversion of U.S. and allied forces* to a third area such as Southwest Asia--i.e., without waiting for a European crisis to emerge

- Measures for *adapting military strategy rapidly to surprising results* from early days of battle--e.g., measures exploiting possible Pact coalition problems as well as measures compensating for unanticipated NATO problems
- Measures for *efficient use of existing war reserve stocks* both in Europe and the United States, including measures that would require early preparation of reservists
- Measures for invoking various degrees of *industrial mobilization* rapidly during periods of high tension--before full-scale mobilization of forces if possible, but as soon as feasible in any event, with attention paid to production of high-effectiveness weapons and spare parts

## V. CONCLUSIONS AND RECOMMENDATIONS

The basic thrust of this paper is that concepts and techniques are now emerging that could be a unifying influence for strategic analysis of NATO issues. These will make possible *multiscenario analysis and the development and testing (through simulation) of complex strategies* incorporating a diversity of ideas and capabilities, and reflecting recognition that operational strategy should be adaptive and multifaceted. It is possible that greater consensus will develop within the several analytic and strategic communities, and that this in turn will influence policy.

To achieve such lofty ambitions will be a good trick, but there are ways to start. In my view, such a start would involve a NATO-wide professional association, with NATO sanction, that would seek to bring together the several groups to which I have alluded with the purpose of improving prospects for modeler-analysts (working at varied levels of detail), technologists, and strategists being able to speak in a common language and calibrate their assumptions. Subsequently, it would be useful to compare multiscenario balance assessments--with the objective of seeing whether agreement can be reached on the *complex* strategies and sets of capabilities needed by NATO in the face of continuing threat and uncertainty.

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